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Herbicide Effectiveness Monitoring on the Ouachita National Forest for Water Quality in the Fiscal Years of 1989 through 1993

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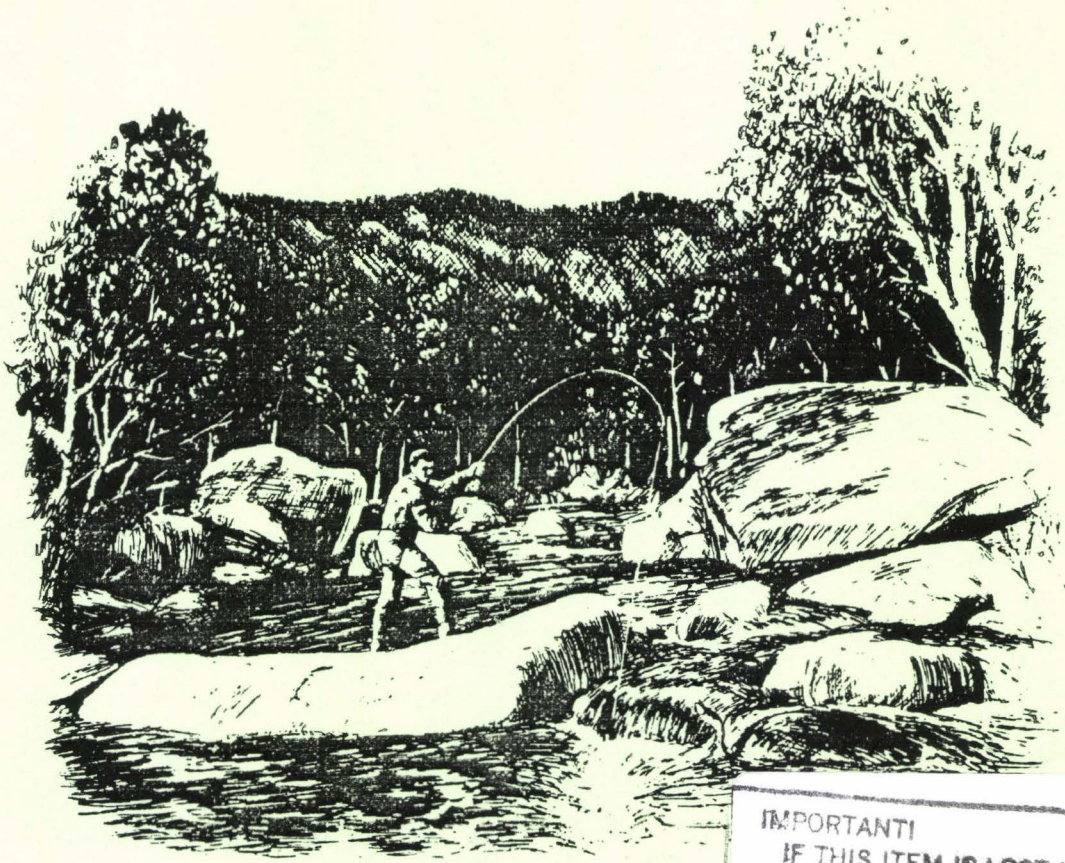

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Herbicide Effectiveness Monitoring on the Ouachita National Forest for Water Quality in the Fiscal Years of 1989 through 1993

(a five year summary)

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Purpose

Herbicide application is one tool used on the Ouachita National Forest to manage vegetation. The application may be for numerous objectives such as understory removal for Red Cockaded Woodpeckers (wildlife habitat improvement), the eradication of Poison Ivy in a campground (noxious weed) or to remove undesirable vegetation so that young trees may grow or be planted (release and site preparation).

When herbicides are applied there is a risk that the herbicide could be spilled, misapplied or move offsite. Several methods or processes are in place to insure that the herbicides are applied properly and contained to the target area. The Forest Service has specific regulations for the use and application of herbicides, and the Ouachita National Forest has additional standards or guidelines that are required. These standards and guidelines are referred to as Best Management Practices (BMPs). BMPs are designed to include federal, state and local regulations. The standards and guidelines for herbicide application are found in the 1990 Ouachita National Forest Amended Land and Resource Management Plan and the 1990 Final Environmental Impact Statement for Vegetation Management in the Ozark/Ouachita Mountains.

Three levels of monitoring are recognized; implementation, effectiveness and validation. Implementation monitoring is the proper and complete application of BMPs involving herbicide usage (did we do what we said we would do). When all BMPs or regulations are implemented then there should be no significant movement of herbicide offsite. Validation monitoring would determine the affect of herbicide concentrations on fisheries, typically in a research sense. Effectiveness monitoring addresses the adequacies of BMP's in their protection of water quality (did they work). For the purposes of effectiveness monitoring and this study, the introduction of herbicide into a water course in high enough quantities to pose a threat to human health, aquatic organisms or exceeding federal, state or local water quality standards would be significant.

Objective

Herbicide applications are monitored for effectiveness in protecting water quality. If BMPs are properly designed and implemented, is there a significant impact on water quality? The objective is to determine if herbicides are present in water in high enough quantities to pose a threat to human health or aquatic organisms. This would indicate ineffective BMP's.

Methodology

The first step in monitoring was the selection of units to be monitored. Each district identified a ten percent sample for each type of herbicide applied. For example if 500 acres were to be treated with Roundup, then at least 50 acres were monitored for Roundup. This could be a single unit or a composite of several units.

Prior to 1990, monitoring purposes were largely limited to site preparation and timber stand improvement treatments. Care was taken to include monitoring of other purposes such as applications under special use permits, for recreation objectives or wildlife stand improvement.

The units to be monitored were selected based on the sensitivity criteria listed below. All units to be monitored contained a streamcourse adjacent to or within it.

1. The treated unit is above a domestic or public water intake.
2. The unit is adjacent to private land, campground or other area that has a potential for public contact.
3. A fishery is located near the unit (or the unit borders a perennial stream.)
4. More than 40% of a watershed is treated.
5. Units treated early in the season.

After the units were prioritized based on the sensitivity criteria, the sample sites were selected. Sample sites were selected as close as possible to the treated area without having to access the sample site through the treated area.

Sample Collection

Water samples were taken from the water course adjacent to or within the treatment area. Samples were scheduled for collection after the first 0.5 inch of rain following treatment. If the sample site was dry then it was revisited with subsequent precipitation. Second and third samples were collected with subsequent storms.

Sample bottles taken to the field were bagged in plastic to prevent contamination prior to use. Personnel taking the samples approached the sample location from downstream and outside of the treatment area. The sample was taken upstream of the sampler. Latex gloves were worn at the time of sampling to ensure that the sample did not become contaminated. Where flow permitted the sample bottles was immersed and filled to within 1 inch of the top. Approximately 450 ml of sample was collected.

The sample was placed on ice. Upon return to the station, samples were frozen to preserve them until they were shipped to the laboratory.

When several samples were ready for shipment the frozen samples were packaged in a disposable styrofoam ice chest. Velpar and Garlon samples were shipped to:

U. G. A. Extension Poultry Science
Riverbend Research Center
110 Riverbend Road
Athens, GA 30605

Roundup samples were sent to:

A and S Environmental Testing, Inc.
Maidencreek Industrial Park
R. D. 2 Box 21398
Reading, PA 19605

The first and second samples collected were sent for analysis. The third sample remained stored until the results of the first samples were known. The third sample was analyzed only if the first or second sample were positive.

Water samples were collected from a variety of methods including soil spot, cut surface, basal spray, hand foliar and mechanical foliar spray throughout the year and. All Forest Service applications were made by hand. Most permittees right of way applications were mechanical.

Laboratory Procedure

The source for the analytical methods for each chemical is listed below:

Garlon - The procedure followed is found in the article by P.B. Bush, D.G. Neary and J.W. Taylor. 1986. Effect of triclopyr amine and ester formulation on ground water and surface water runoff quality. Proc S. Weed Sci. Soc. 39. pages 226-232. and is referred to within the lab as SOP 330-EX: Analytical Technique for the Determination of Triclopyr Residues in Water [Rev. 1.0].

Velpar - The procedure followed is found in the article by D.G. Neary, P.B. Bush and J. Douglas. 1983. Offsite move of hexazinone in stormflow and baseflow in forest watersheds. Weed Sci. vol 31 543-551. and is referred to within the lab as SOP 326-EX: Analytical Technique for the Determination of Hexazinone Residues in Water [Rev 1.0]

Roundup - The procedure followed was a Monsanto supplied method entitled "Analytical Residue Method for N-Phosphonomethyl Glycine and Aminomethyl Phosphonic Acid in Raw Agricultural Commodities and Water."

Scan - The procedure is found in the Standard Operating Procedures of the Agricultural Services Laboratory at the University of Georgia entitled SOP 400-EX: How to Extract and Analyze Nitrogen Herbicide Residues from Soil and Sediments [Rev. 1.0]

Reporting

When samples were shipped directly to the lab from the District Office the following information was forwarded to the Supervisors Office of the Ouachita National Forest:

District:
Compartment:
Stand:
Herbicide used:
Method of application:
Purpose of application:
Actual application rate:
Person taking samples:
Dates of application, sampling and shipping:
Map showing the treated area and sample area (1:24000):
Acres of the treated area being monitored:
Acres of area of the watershed above the sample site:
Any comments or observations about the sample site, application or problems encountered should also be included:
In addition a brief summary of the total acres treated by each herbicide should be included.

Laboratory results were compiled and delivered to the Supervisors Office of the Ouachita National Forest.

Results

Over the five year period from 1989 through 1993 samples were collected from all twelve ranger districts. The herbicides monitored for were Roundup (glyphosphate), Velpar (hexazinone) and Garlon (triclopyr).

Garlon

The sample results for Garlon are listed in Appendix A. EPA lists a residue limit for milk is 0.0100 parts per million (ppm) and a temporary potable water residue limit of 0.500 ppm. Garlon 3a must be present in streams in concentrations greater than 100.0 ppm before fish are affected. Garlon 4 is more toxic with LC50's of 0.79 and 0.87 ppm for rainbow trout and bluegill, respectively. The highest concentration of Garlon detected was 0.144 ppm (FY 1990). No concentrations were detected that would negatively affect fisheries. A summary of Garlon monitoring results is displayed in the following table.

Garlon Monitoring Summary

	FY 89	FY 90	FY 91	FY 92	FY 93	Overall
# Sites	19	29	22	18	10	98
# Samples	37	66	53	41	19	216
# of Positive Samples	11	17	4	14	5	51
% Positive Samples	29.7%	25.8%	7.5%	34.1%	26.3%	23.6%
method						
cut surface	31	62	27	31	7	158
hand foliar	6	2	16	7	3	34
mech. foliar	0	2	0	0	7	9
basal stem	0	0	10	3	2	15
purpose						
site prep.	23	44	21	22	6	116
release	14	16	30	15	3	78
row	0	2	0	0	10	12
wildlife	0	4	2	4	0	10
noxious	0	0	0	0	0	0

Positive Samples

	FY 89	FY 90	FY 91	FY 92	FY 93	Overall
method						
cut surface	8	17	3	8	2	38
hand foliar	3	0	1	4	0	8
mech. foliar	0	0	0	0	2	2
basal stem	0	0	0	2	0	2
purpose						
site prep.	7	11	1	5	2	26
release	4	6	3	9	1	23
row	0	0	0	0	2	2
wildlife	0	0	0	0	0	0
noxious	0	0	0	0	0	0

Overall, 98 sites were monitored and 216 samples were analyzed. Of those samples 51 (23.6%) had detectable levels of Garlon. As previously noted, none of these levels were of a high enough concentration to negatively affect fisheries (the first beneficial use encountered). Site preparation (a purpose for treatment) was monitored the most intensively with 116 samples, and cut surface was the most intensively monitored application method with 158 samples.

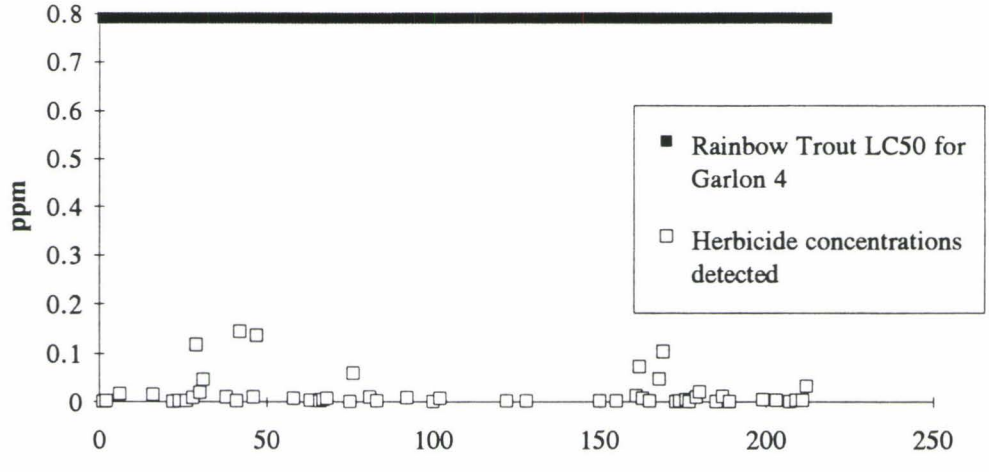
In order to determine if any purpose or method had a higher instance of detectable levels the percent of positive samples to total samples by method and purpose are displayed in the following table.

Percent Positive Garlon Summary by Method and Purpose

	FY 89	FY 90	FY 91	FY 92	FY 93	Overall
method						
cut surface	25.8%	27.4%	11.1%	25.8%	28.6%	24.1%
hand foliar	50.0%	0.0%	6.3%	57.1%	0.0%	23.5%
mech. foliar		0.0%			28.6%	22.2%
basal stem			0.0%	66.7%	0.0%	13.3%
purpose						
site prep.	30.4%	25.0%	4.8%	22.7%	33.3%	22.4%
release	28.6%	37.5%	10.0%	60.0%	33.3%	29.5%
row		0.0%			20.0%	16.7%
wildlife		0.0%	0.0%	0.0%		0.0%
noxious						

Overall no single method or purpose resulted in higher occurrences of offsite Garlon detection. Release had the highest occurrence at 29.5% and basal stem applications had the lowest occurrence of methods at 13.3%.

Garlon concentrations and residue limits



Roundup

The sample results for Roundup are listed in Appendix A. EPA lists a potable water residue limit for Roundup of 0.100 ppm. Levels toxic to fish begin to occur at 2.0 ppm. No concentrations were detected that would negatively affect fisheries. A summary of Roundup

monitoring is displayed in the following table.

Roundup Monitoring Summary

	FY 89	FY 90	FY 91	FY 92	FY 93	Overall
# Sites	0	14	11	8	4	37
# Samples	0	32	22	16	8	78
# of Positive Samples	0	5	3	0	0	8
% Positive Samples		15.6%	13.6%	0.0%	0.0%	10.3%
method						
cut surface	0	9	4	10	0	23
hand foliar	0	10	8	6	0	24
mech. foliar	0	13	10	0	8	31
basal stem	0	0	0	0	0	0
purpose						
site prep.	0	0	2	8	0	10
release	0	15	10	8	0	33
row	0	13	10	0	8	31
wildlife	0	0	0	0	0	0
noxious	0	4	0	0	0	6

Positive Samples

	FY 89	FY 90	FY 91	FY 92	FY 93	Overall
method						
cut surface	0	0	1	0	0	1
hand foliar	0	1	0	0	0	1
mech. foliar	0	4	2	0	0	6
basal stem	0	0	0	0	0	0
purpose						
site prep.	0	0	0	0	0	0
release	0	1	0	0	0	1
row	0	4	2	0	0	6
wildlife	0	0	0	0	0	0
noxious	0	0	1	0	0	1

Overall, 37 sites were monitored and 78 samples were analyzed. Of those samples 8 (13.3%) had detectable levels of Roundup. As previously noted, none of these levels were of a high enough concentration to negatively affect fisheries (the first beneficial use encountered). Methods and purposes where the predominance of monitoring occurred were mechanical foliar spray (31 samples), and release and right of way maintenance (33 and 31 samples, respectively).

In order to determine if any purpose or method has a higher incidence of detectable levels the percent of positive samples to total samples by method and purpose are displayed in the following table.

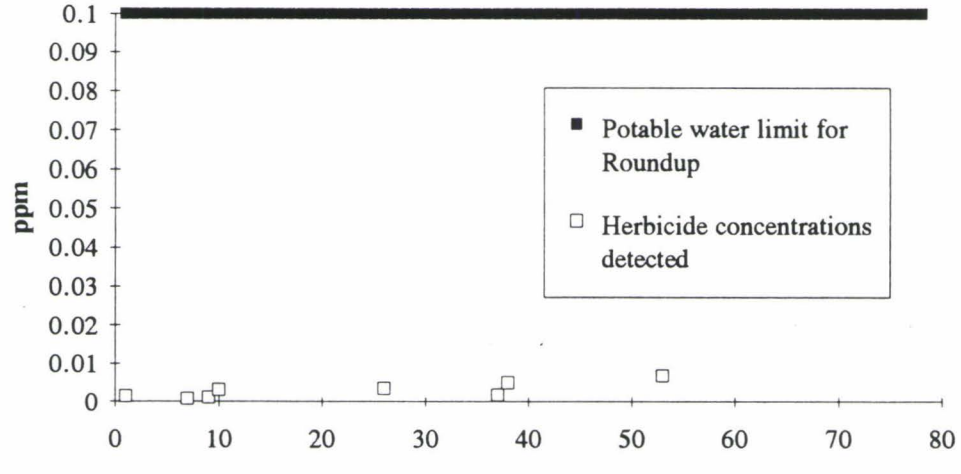
Percent Positive Roundup Summary by Method and Purpose

	FY 89	FY 90	FY 91	FY 92	FY 93	Overall
method						
cut surface		0.0%	25.0%	0.0%		4.3%
hand foliar		10.0%	0.0%	0.0%		4.2%
mech. foliar		30.8%	20.0%		0.0%	19.4%
basal stem						
purpose						
site prep.			0.0%	0.0%		0.0%
release		6.7%	0.0%	0.0%		3.0%
row		30.8%	20.0%		0.0%	19.4%
wildlife						
noxious		0.0%				16.7%

Right of way maintenance using mechanical foliar application had the highest incidence of detection at 19.4% (31 samples) of all samples having detectable levels of Roundup. Noxious weed control had a 16.7% instance of detectable levels of Roundup with one sample out of six being positive.

To graphically display the level of concentrations and risk to beneficial uses the following graph is presented with all Roundup concentrations detected compared with the potable water limit.

Roundup concentrations and residue limits



Velpar

The sample results for Velpar are listed in Appendix A. EPA does not list a potable water residue limit for Velpar, however, the residue limit for milk is 0.100 ppm. Concentrations necessary to affect fisheries would have to be above 100.0 ppm. The highest concentration of Velpar detected was 0.0150 ppm in FY 1991. No concentrations were detected that would negatively affect fisheries. A summary of Velpar monitoring results is displayed in the following table.

Velpar Monitoring Summary

	FY 89	FY 90	FY 91	FY 92	FY 93	Overall
# Sites	19	5	8	1	0	33
# Samples	29	9	14	2	0	54
# of Positive Samples	6	1	3	0	0	10
% Positive Samples	20.7%	11.1%	21.4%	0.0%		18.5%
method						
cut surface	2	0	1	0	0	3
soil spot	27	9	13	2	0	51
purpose						
site prep.	24	9	13	2	0	48
release	5	0	1	0	0	6

Positive samples

	FY 89	FY 90	FY 91	FY 92	FY 93	Overall
method						
cut surface	0	0	0	0	0	0
soil spot	6	1	3	0	0	10
purpose						
site prep.	6	1	3	0	0	10

Overall, 33 sites were monitored and 54 samples were analyzed. Of those samples 10 (18.5%) had detectable levels of Velpar. As previously noted, none of these levels were of a concentration to negatively affect fisheries (the first beneficial use encountered). Site preparation (48 samples) was the most intensively monitored purpose and soil spot application (51 samples) was the most intensively monitored method.

In order to determine if any purpose or method has a higher incidence of detectable residue the percent of positive samples to total samples by method and purpose are displayed in the following table.

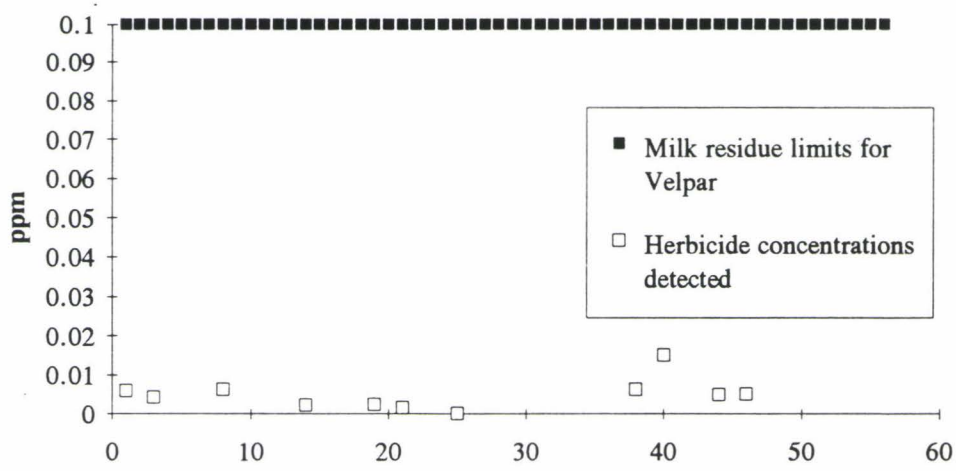
Percent Positive Velpar Summary by Method and Purpose

	FY 89	FY 90	FY 91	FY 92	FY 93	Overall
method						
cut surface	0.0%		0.0%			0.0%
soil spot	22.2%	11.1%	23.1%	0.0%		19.6%
purpose						
site prep.	25.0%	11.1%	23.1%	0.0%		20.8%
release	0.0%		0.0%			0.0%

Of the limited methods and purposes monitored, soil spot applications and site preparation had the highest percentages of offsite herbicide detection.

To graphically display the level of concentrations and risk to beneficial uses the following graph is presented with all concentrations for Velpar detected compared to the residue tolerance for milk.

Velpar concentrations and residue limits



Other experiments

In the early winter of 1990 monitoring identified the presence of Garlon residue in a pond and stream on private property. As previously noted these concentrations detected were well below levels that would negatively affect beneficial uses (in this case domestic water, livestock water and fish). At the request of the landowner the ponds and stream were monitored for an additional six months. After the second set of storm samples Garlon was not detected. In addition; groundwater, fish organs and flesh, beef organs, and soil samples were analyzed and found to have no detectable levels of Garlon.

In 1990 the Choctaw District monitored a right of way application conducted by the Highway Department. In addition to monitoring for the known herbicide a broad scan was conducted for other contaminants. The following herbicides were scanned for:

Herbicide Scan

Herbicide	Detection Limit	Herbicide	Detection Limit
Atrazine	0.007	Lasso	0.030
Balan	0.030	Ordram	0.045
Bravo	0.030	Oxadizon	0.016
Bromacil	0.013	Paarlan	0.035
Devrinol	0.013	Propachlor	0.130
Dimethoate	0.034	Propazine	0.030
Dual	0.030	Prowl	0.030
Eptam	0.027	Roneet	0.063
Goal	0.030	Sencor	0.020
Velpar	0.010	Simazine	0.020
Tolban	0.065	Sutan	0.020
Treflan	0.030	Terbacil	0.013
Vernam	0.009	Tillam	0.051

None of these herbicides were detected in any of the samples.

Quality Assurance

In 1990 the monitoring methodology was reviewed and revised. In spring of that year each district was trained in proper site selection, access, sample collection, sample preservation and transportation of samples. These protocols have remained in place since April of 1990.

Through personal communications with the herbicide companies, labs were selected that were using proper test procedures. Dow Elanco Chemical Company posed a concern over the lab procedure the University of Georgia was using for Garlon. In 1990, duplicate samples were collected and sent to the University of Georgia lab and a lab recommended by Dow Elanco. The Georgia lab was using the method described in SOP 330-EX and the Dow Elanco lab used ACR 76.8 method (a confidential Dow Elanco method). Thirty-four duplicate samples were submitted to both labs. Of those samples, 10 had detectable herbicide concentrations from the University of Georgia Lab and six had detectable levels from the Dow Elanco lab. The results are displayed in Appendix B. Of the concentration levels detected the University of Georgia concentrations were roughly twice as high. Based on the evidence that the University of Georgia lab provided more conservative results (more detections and higher concentrations) and lower cost per sample the decision was to remain with the University of Georgia lab and accept the possible risk of that conservatism.

Summary and Conclusions

From 1989 through 1993, 168 sites and 348 water samples were analyzed for the presence of herbicides. Herbicides monitored for included Garlon, Velpar and Roundup. Of those

samples, 69 had detectable levels of herbicide. No concentrations were detected that would pose a significant threat to beneficial uses. Based on this evaluation the Best Management Practices used in the transportation, mixing, application and disposal are effective at protecting beneficial uses.

From this study the following recommendations are submitted:

- The monitoring of herbicide movement into surface waters should continue.
- Continue to emphasis monitoring all methods and purposes of herbicide treatment.
- Review the effect of additional BMP's.
- Presently the Phase II ecosystem management research effort is studying the offsite movement of Garlon. Based on the results of that study the current sampling protocols should be reviewed and modified if necessary.

Appendix A

Garlon Monitoring Results

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Caddo	18	10	cut surface	site prep.	89	0.0011	0.0010
Caddo	18	10	cut surface	site prep.	89	nd	0.0010
Caddo	28	8	cut surface	site prep.	89	0.0022	0.0010
Caddo	28	8	cut surface	site prep.	89	nd	0.0010
Cold Spr.	240	11	cut surface	site prep.	89	nd	0.0010
Cold Spr.	240	11	cut surface	site prep.	89	nd	0.0010
Cold Spr.	325	23.2	cut surface	site prep.	89	nd	0.0010
Cold Spr.	325	23.3	cut surface	site prep.	89	0.0171	0.0010
Cold Spr.	325	23.3	cut surface	site prep.	89	nd	0.0010
Cold Spr.	325	23.3	cut surface	site prep.	89	nd	0.0010
Cold Spr.	325	23.3	cut surface	site prep.	89	nd	0.0010
Cold Spr.	325	23.3	cut surface	site prep.	89	nd	0.0010
Cold Spr.	325	23.4	cut surface	site prep.	89	nd	0.0010
Fourche	413	5	cut surface	release	89	nd	0.0010
Fourche	413	5	cut surface	release	89	nd	0.0010
Fourche	434	5,4	cut surface	release	89	nd	0.0010
Fourche	434	5,4	cut surface	release	89	nd	0.0010
Fourche	454	4	cut surface	release	89	0.0149	0.0010
Fourche	454	4	cut surface	release	89	nd	0.0010
Fourche	483	13	cut surface	release	89	nd	0.0010
Fourche	483	13	cut surface	release	89	nd	0.0010
Fourche	509	7,10	cut surface	site prep.	89	nd	0.0010
Fourche	509	7,10	cut surface	site prep.	89	nd	0.0010
Mena	895	18	hand foliar	release	89	0.0012	0.0010
Mena	895	18	hand foliar	release	89	nd	0.0010
Mena	896	6(1)	hand foliar	release	89	0.0020	0.0010
Mena	896	6(2)	hand foliar	release	89	nd	0.0010
Mena	899	12	hand foliar	release	89	0.0022	0.0010
Mena	899	12	hand foliar	release	89	nd	0.0010
Oden	1084	11(1)	cut surface	site prep.	89	0.0081	0.0010
Oden	1084	11(1)	cut surface	site prep.	89	0.1170	0.0010
Oden	1084	11(2)	cut surface	site prep.	89	0.0201	0.0010
Oden	1084	11(2)	cut surface	site prep.	89	0.0460	0.0010
Oden	1090	7,8	cut surface	site prep.	89	nd	0.0010
Oden	1090	7,8	cut surface	site prep.	89	nd	0.0010
Womble	1676	26	cut surface	site prep.	89	nd	0.0010
Womble	1682	1	cut surface	site prep.	89	nd	0.0010
Caddo	35	2	cut surface	site prep.	90	0.0103	0.0010
Caddo	35	2	cut surface	site prep.	90	nd	0.0010
Caddo	35	2	cut surface	site prep.	90	nd	0.0010
Caddo	55	5	cut surface	site prep.	90	0.0014	0.0010
Caddo	55	5	cut surface	site prep.	90	0.1440	0.0010
Caddo	55	5	cut surface	site prep.	90	nd	0.0010
Caddo	97	8	cut surface	site prep.	90	nd	0.0010
Caddo	97	8	cut surface	site prep.	90	nd	0.0010
Caddo	113	6	cut surface	site prep.	90	0.0104	0.0010
Caddo	113	6	cut surface	site prep.	90	0.1368	0.0010

Garlon Monitoring Results (continued)

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Caddo	113	6	cut surface	site prep.	90	nd	0.0010
Cold Spr.	239	9	cut surface	site prep.	90	nd	0.0010
Cold Spr.	244	25	cut surface	site prep.	90	nd	0.0010
Cold Spr.	325	23	cut surface	site prep.	90	nd	0.0010
Cold Spr.	325	23	cut surface	site prep.	90	nd	0.0010
Cold Spr.	325	23	cut surface	site prep.	90	nd	0.0010
Cold Spr.	325	23	cut surface	site prep.	90	nd	0.0010
Cold Spr.	325	23	cut surface	site prep.	90	nd	0.0010
Cold Spr.	325	23	cut surface	site prep.	90	nd	0.0010
Fourche	419	16	cut surface	site prep.	90	0.0077	0.0010
Fourche	419	16	cut surface	site prep.	90	nd	0.0010
Fourche	419	16	cut surface	site prep.	90	nd	0.0010
Fourche	435	5	cut surface	site prep.	90	nd	0.0010
Fourche	435	5	cut surface	site prep.	90	nd	0.0010
Fourche	453	4	cut surface	site prep.	90	0.0031	0.0010
Fourche	453	4	cut surface	site prep.	90	nd	0.0010
Fourche	453	4	cut surface	site prep.	90	nd	0.0010
Fourche	466	4	cut surface	release	90	0.0018	0.0010
Fourche	466	4	cut surface	release	90	0.0046	0.0010
Fourche	466	4	cut surface	release	90	0.0078	0.0010
Fourche	477	16/22	cut surface	wildlife	90	nd	0.0010
Fourche	477	16/22	cut surface	wildlife	90	nd	0.0010
Fourche	489	8	cut surface	wildlife	90	nd	0.0010
Fourche	489	8	cut surface	wildlife	90	nd	0.0010
Jessieville	639	23	hand foliar	release	90	nd	0.0010
Jessieville	639	23	hand foliar	release	90	nd	0.0010
Kiamichi	222	6	cut surface	release	90	0.0013	0.0010
Kiamichi	222	6	cut surface	release	90	0.0591	0.0010
Kiamichi	232	7	cut surface	release	90	nd	0.0010
Kiamichi	232	7	cut surface	release	90	nd	0.0010
Kiamichi	250	19	cut surface	release	90	nd	0.0010
Kiamichi	250	19	cut surface	release	90	nd	0.0010
Kiamichi	259	2	cut surface	release	90	0.0106	0.0010
Kiamichi	259	2	cut surface	release	90	nd	0.0010
Oden	1102	19	cut surface	site prep.	90	0.0018	0.0010
Oden	1102	19	cut surface	site prep.	90	nd	0.0010
Poteau	1273	12	cut surface	release	90	nd	0.0010
Womble	1615	RoW	mech. foliar	row	90	nd	0.0010
Womble	1615	RoW	mech. foliar	row	90	nd	0.0010
Womble	1628	9	cut surface	site prep.	90	nd	0.0010
Womble	1628	9	cut surface	site prep.	90	nd	0.0010
Womble	1641	22	cut surface	site prep.	90	nd	0.0010
Womble	1641	22	cut surface	site prep.	90	nd	0.0010
Womble	1643	29	cut surface	site prep.	90	0.0090	0.0010
Womble	1643	29	cut surface	site prep.	90	nd	0.0010
Womble	1643	35	cut surface	site prep.	90	nd	0.0010
Womble	1643	35	cut surface	site prep.	90	nd	0.0010
Womble	1659	5	cut surface	release	90	nd	0.0010
Womble	1659	5	cut surface	release	90	nd	0.0010
Womble	1672	6	cut surface	site prep.	90	nd	0.0010

Garlon Monitoring Results (continued)

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Womble	1672	6	cut surface	site prep.	90	nd	0.0010
Womble	1679	7	cut surface	site prep.	90	0.0010	0.0010
Womble	1679	7	cut surface	site prep.	90	nd	0.0010
Womble	1688	8	cut surface	site prep.	90	0.0070	0.0010
Womble	1688	8	cut surface	site prep.	90	nd	0.0010
Caddo	12	9	cut surface	site prep.	91	nd	0.0010
Caddo	12	9	cut surface	site prep.	91	nd	0.0010
Caddo	12	9	cut surface	site prep.	91	nd	0.0010
Caddo	94	10	cut surface	site prep.	91	nd	0.0010
Caddo	94	10	cut surface	site prep.	91	nd	0.0010
Caddo	94	10	cut surface	site prep.	91	nd	0.0010
Cold Spr.	230	10	basal stem	release	91	nd	0.0010
Cold Spr.	230	10	basal stem	release	91	nd	0.0010
Cold Spr.	230	10	basal stem	release	91	nd	0.0010
Cold Spr.	230	10	basal stem	release	91	nd	0.0010
Cold Spr.	232	14	cut surface	site prep.	91	nd	0.0010
Cold Spr.	232	14	cut surface	site prep.	91	nd	0.0010
Cold Spr.	225/226	11,5	basal stem	site prep.	91	nd	0.0010
Cold Spr.	225/226	11,5	basal stem	site prep.	91	nd	0.0010
Cold Spr.	225/226	11,5	basal stem	site prep.	91	nd	0.0010
Cold Spr.	225/226	11,5	basal stem	site prep.	91	nd	0.0010
Cold Spr.	225/226	11,5	basal stem	site prep.	91	nd	0.0010
Cold Spr.	225/226	11,5	basal stem	site prep.	91	nd	0.0010
Fourche	410	10,14	cut surface	site prep.	91	0.0014	0.0010
Fourche	410	10,14	cut surface	site prep.	91	nd	0.0010
Fourche	463	1	cut surface	release	91	nd	0.0010
Fourche	463	1	cut surface	release	91	nd	0.0010
Jessieville	614	7,11	hand foliar	release	91	nd	0.0010
Jessieville	614	7,11	hand foliar	release	91	nd	0.0010
Jessieville	662	20	hand foliar	release	91	0.0014	0.0010
Jessieville	662	20	hand foliar	release	91	nd	0.0010
Mena	929	1	hand foliar	release	91	nd	0.0010
Mena	929	1	hand foliar	release	91	nd	0.0010
Mena	929	BrownSpg	hand foliar	release	91	nd	0.0010
Mena	929	BrownSpg	hand foliar	release	91	nd	0.0010
Mena	941	9	hand foliar	release	91	nd	0.0010
Mena	941	9	hand foliar	release	91	nd	0.0010
Mena	948	2	hand foliar	release	91	nd	0.0010
Mena	948	2	hand foliar	release	91	nd	0.0010
Poteau	1237	11	hand foliar	release	91	nd	0.0010
Poteau	1237	11	hand foliar	release	91	nd	0.0010
Poteau	1258	4	cut surface	release	91	nd	0.0010
Poteau	1258	4	cut surface	release	91	nd	0.0010
Poteau	1310	14/13	cut surface	release	91	nd	0.0010
Poteau	1310	14/13	cut surface	release	91	nd	0.0010
Winona	1465	2	hand foliar	release	91	nd	0.0010
Winona	1465	2	hand foliar	release	91	nd	0.0010
Womble	1618	8	cut surface	site prep.	91	nd	0.0010
Womble	1618	8	cut surface	site prep.	91	nd	0.0010

Garlon Monitoring Results (continued)

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Womble	1625	10	cut surface	wildlife	91	nd	0.0010
Womble	1625	10	cut surface	wildlife	91	nd	0.0010
Womble	1654	37	cut surface	release	91	0.0014	0.0010
Womble	1654	37	cut surface	release	91	nd	0.0010
Womble	1656	10	cut surface	site prep.	91	nd	0.0010
Womble	1656	10	cut surface	site prep.	91	nd	0.0010
Womble	1656	10	cut surface	site prep.	91	nd	0.0010
Womble	1690	23	cut surface	release	91	0.0017	0.0010
Womble	1690	23	cut surface	release	91	nd	0.0010
Cold Spr.	259	16	cut surface	site prep.	92	nd	0.0010
Cold Spr.	259	16	cut surface	site prep.	92	nd	0.0010
Cold Spr.	277	1	cut surface	site prep.	92	nd	0.0010
Cold Spr.	277	1	cut surface	site prep.	92	nd	0.0010
Fourche	512	12	cut surface	release	92	0.0130	0.0010
Fourche	512	12	cut surface	release	92	0.0730	0.0010
Fourche	513	10	cut surface	release	92	0.0077	0.0010
Fourche	513	10	cut surface	release	92	nd	0.0010
Mena	904	15	hand foliar	release	92	0.0017	0.0010
Mena	904	15	hand foliar	release	92	nd	0.0010
Mena	904	15	hand foliar	release	92	nd	0.0010
Mena	928	5	hand foliar	release	92	0.0470	0.0010
Mena	928	5	hand foliar	release	92	0.1040	0.0010
Mena	928	5	cut surface	release	92	0.0325	0.0010
Mena	935	4,5,13	cut surface	site prep.	92	nd	0.0010
Mena	935	4,5,13	cut surface	site prep.	92	nd	0.0010
Mena	935	4,5,13	cut surface	site prep.	92	nd	0.0010
Mena	935	8,19	basal stem	site prep.	92	0.0012	0.0010
Mena	935	8,19	basal stem	site prep.	92	0.0022	0.0010
Mena	935	8,19	basal stem	site prep.	92	nd	0.0010
Mena	953	1	hand foliar	release	92	0.0042	0.0010
Mena	953	1	hand foliar	release	92	nd	0.0010
Oden	1060	3	cut surface	site prep.	92	0.0100	0.0010
Oden	1060	3	cut surface	site prep.	92	0.0204	0.0010
Oden	1060	3	cut surface	site prep.	92	nd	0.0010
Oden	1060	3	cut surface	site prep.	92	nd	0.0010
Oden	1131	12	cut surface	site prep.	92	nd	0.0010
Oden	1131	12	cut surface	site prep.	92	nd	0.0010
Poteau	1249	11	cut surface	release	92	nd	0.0010
Winona	1416	20	cut surface	site prep.	92	0.0108	0.0010
Winona	1416	20	cut surface	site prep.	92	nd	0.0010
Womble	1627	8	cut surface	release	92	0.0012	0.0010
Womble	1627	8	cut surface	release	92	nd	0.0010
Womble	1629	24	cut surface	wildlife	92	nd	0.0010
Womble	1629	24	cut surface	wildlife	92	nd	0.0010
Womble	1679	30	cut surface	site prep.	92	nd	0.0010
Womble	1679	30	cut surface	site prep.	92	nd	0.0010
Womble	1685	11	cut surface	wildlife	92	nd	0.0010
Womble	1685	11	cut surface	wildlife	92	nd	0.0010

Garlon Monitoring Results (continued)

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Womble	1687	8	cut surface	site prep.	92	nd	0.0010
Womble	1687	8	cut surface	site prep.	92	nd	0.0010
Caddo	67	9,dirt16,37	cut surface	site prep.	93	0.0045	0.0010
Caddo	67	9,dirt16,37	cut surface	site prep.	93	nd	0.0010
Caddo	67	9,pave16	cut surface	site prep.	93	nd	0.0010
Caddo	67	9,pave16	cut surface	site prep.	93	nd	0.0010
Cold Spr.	262	2,4,6,9,10	cut surface	site prep.	93	0.0029	0.0010
Cold Spr.	262	2,4,6,9,10	cut surface	site prep.	93	nd	0.0010
Fourche	453	4	basal stem	release	93	nd	0.0010
Fourche	453	4	basal stem	release	93	nd	0.0010
Fourche	501	1,9,10,12	cut surface	release	93	0.0011	0.0010
Kiamichi	KiaElec	1	mech. foliar	row	93	nd	0.0010
Kiamichi	KiaElec	2	mech. foliar	row	93	0.0032	0.0010
Kiamichi	KiaElec	1a	mech. foliar	row	93	nd	0.0010
Kiamichi	KiaElec	2a	mech. foliar	row	93	0.0037	0.0010
Mena	967	tallpeak	hand foliar	row	93	nd	0.0010
Mena	967	state 1	mech. foliar	row	93	nd	0.0010
Mena	967	state 2	mech. foliar	row	93	nd	0.0010
Mena	967	state 1	mech. foliar	row	93	nd	0.0010
Mena	971	tallpeak	hand foliar	row	93	nd	0.0010
Mena	972	tallpeak	hand foliar	row	93	nd	0.0010

Roundup Monitoring Results

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Caddo	20	11	hand foliar	release	90	0.0015	0.0005
Caddo	20	11	hand foliar	release	90	nd	0.0005
Caddo	100	2	cut surface	release	90	nd	0.0005
Caddo	100	2	cut surface	release	90	nd	0.0005
Choctaw	hwy259		mech. foliar	row	90	nd	0.0005
Choctaw	hwy270	59(1)	mech. foliar	row	90	nd	0.0005
Choctaw	hwy271	1004	mech. foliar	row	90	0.0007	0.0005
Choctaw	hwy271	59(1)	mech. foliar	row	90	nd	0.0005
Choctaw	hwy272	1004	mech. foliar	row	90	0.0010	0.0005
Choctaw	hwy272	59(2)	mech. foliar	row	90	0.0031	0.0005
Choctaw	hwy273	59(2)	mech. foliar	row	90	nd	0.0005
Fourche	497	14	hand foliar	release	90	nd	0.0005
Mena	925	5	hand foliar	release	90	nd	0.0005
Mena	925	5	hand foliar	release	90	nd	0.0005
Poteau	1251	15/16	cut surface	release	90	nd	0.0005
Poteau	1251	15/16	cut surface	release	90	nd	0.0005
Poteau	1251	15/16	cut surface	release	90	nd	0.0005
Poteau	1252	9	cut surface	release	90	nd	0.0005
Poteau	1252	9	cut surface	release	90	nd	0.0005
Poteau	1252	9	cut surface	release	90	nd	0.0005
Poteau	1260	15	cut surface	release	90	nd	0.0005
Tiak	5	3	hand foliar	noxious	90	nd	0.0005
Tiak	5	3	hand foliar	noxious	90	nd	0.0005
Tiak	5	3	hand foliar	noxious	90	nd	0.0005
Tiak	5	3	hand foliar	noxious	90	nd	0.0005
Tiak	5	3	hand foliar	noxious	90	0.0068	0.0005
Tiak	5	3	hand foliar	noxious	90	nd	0.0005
Tiak	12	16	mech. foliar	row	90	0.0035	0.0005
Tiak	12	16	mech. foliar	row	90	nd	0.0005
Tiak	12	16	mech. foliar	row	90	nd	0.0005
Tiak	12	16	mech. foliar	row	90	nd	0.0005
Womble	1615	RoW	mech. foliar	row	90	nd	0.0005
Womble	1615	RoW	mech. foliar	row	90	nd	0.0005
Fourche	497	14	hand foliar	release	91	nd	0.0005
Fourche	516	1	hand foliar	release	91	nd	0.0005
Fourche	516	1	hand foliar	release	91	nd	0.0005
Fourche	fsrdg03	east	mech. foliar	row	91	nd	0.0005
Fourche	fsrdg03	east	mech. foliar	row	91	nd	0.0005
Fourche	fsrdg03	west	mech. foliar	row	91	0.0019	0.0005
Fourche	fsrdg03	west	mech. foliar	row	91	0.0049	0.0005
Fourche	high27s	1	mech. foliar	row	91	nd	0.0005
Fourche	high27s	1	mech. foliar	row	91	nd	0.0005
Fourche	high27s	2	mech. foliar	row	91	nd	0.0005
Fourche	high27s	2	mech. foliar	row	91	nd	0.0005
Fourche	high27s	3	mech. foliar	row	91	nd	0.0005
Fourche	high27s	3	mech. foliar	row	91	nd	0.0005
Oden	1076	9	hand foliar	site prep.	91	nd	0.0005
Oden	1076	9	hand foliar	site prep.	91	nd	0.0005

Roundup Monitoring Results (continued)

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Oden	1112	1	hand foliar	release	91	nd	0.0005
Oden	1112	1	hand foliar	release	91	nd	0.0005
Poteau	1260	15	cut surface	release	91	nd	0.0005
Poteau	1260	15	cut surface	release	91	nd	0.0005
Poteau	1263	14	cut surface	release	91	nd	0.0005
Poteau	1263	14	cut surface	release	91	nd	0.0005
Fourche	483	10	hand foliar	release	92	nd	0.0005
Fourche	483	10	hand foliar	release	92	nd	0.0005
Fourche	483	13	hand foliar	release	92	nd	0.0005
Fourche	483	13	hand foliar	release	92	nd	0.0005
Fourche	483	19	hand foliar	release	92	nd	0.0005
Fourche	483	19	hand foliar	release	92	nd	0.0005
Oden	1082	2	cut surface	site prep.	92	nd	0.0005
Oden	1082	2	cut surface	site prep.	92	nd	0.0005
Oden	1113	3	cut surface	site prep.	92	nd	0.0005
Oden	1113	3	cut surface	site prep.	92	nd	0.0005
Oden	1117	10	cut surface	site prep.	92	nd	0.0005
Oden	1117	10	cut surface	site prep.	92	nd	0.0005
Oden	1128	4,10	cut surface	site prep.	92	nd	0.0005
Oden	1128	4,10	cut surface	site prep.	92	nd	0.0005
Poteau	1312	7	cut surface	release	92	nd	0.0005
Poteau	1312	7	cut surface	release	92	nd	0.0005
Mena	835	hwy71	mech. foliar	row	93	nd	0.0005
Mena	835	hwy71	mech. foliar	row	93	nd	0.0005
Mena	840	hwy71	mech. foliar	row	93	nd	0.0005
Mena	840	hwy71	mech. foliar	row	93	nd	0.0005
Mena	868	Hwy270	mech. foliar	row	93	nd	0.0005
Mena	868	Hwy270	mech. foliar	row	93	nd	0.0005
Womble	1631	hwy	mech. foliar	row	93	nd	0.0005
Womble	1631	hwy	mech. foliar	row	93	nd	0.0005

Velpar Monitoring Results

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Cold Spr.	296	10	soil spot	site prep.	89	0.0060	0.0015
Cold Spr.	314	29	soil spot	site prep.	89	nd	0.0010
Cold Spr.	324	4	soil spot	site prep.	89	0.0043	0.0010
Fourche	409	9	soil spot	release	89	nd	0.0010
Fourche	441	7	soil spot	release	89	nd	0.0010
Fourche	483	19	soil spot	release	89	nd	0.0010
Fourche	518	10	soil spot	site prep.	89	nd	0.0010
Jessieville	610	4	soil spot	site prep.	89	0.0062	0.0010
Jessieville	610	4	soil spot	site prep.	89	nd	0.0010
Jessieville	628	6	soil spot	site prep.	89	nd	0.0010
Jessieville	628	6	soil spot	site prep.	89	nd	0.0010
Jessieville	629	17	soil spot	site prep.	89	nd	0.0010
Jessieville	629	17	soil spot	site prep.	89	nd	0.0010
Jessieville	630	11,12	soil spot	site prep.	89	0.0022	0.0010
Jessieville	630	11,12	soil spot	site prep.	89	nd	0.0010
Jessieville	674	9	soil spot	site prep.	89	nd	0.0010
Jessieville	674	9	soil spot	site prep.	89	nd	0.0010
Oden	1113	13	soil spot	site prep.	89	nd	0.0015
Poteau	1272	17,18,25	soil spot	site prep.	89	0.0025	0.0015
Poteau	1272	17,18,25	soil spot	site prep.	89	nd	0.0010
Poteau	1294	14	soil spot	site prep.	89	0.0015	0.0015
Poteau	1294	14	soil spot	site prep.	89	nd	0.0010
Poteau	1327	2	soil spot	release	89	nd	0.0015
Poteau	1327	2	soil spot	release	89	nd	0.0010
Winona	1434	25	soil spot	site prep.	89	nd	0.0010
Winona	1448	25	soil spot	site prep.	89	nd	0.0010
Winona	1448	25	soil spot	site prep.	89	nd	0.0015
Womble	1691	16	cut surface	site prep.	89	nd	0.0010
Womble	1691	16	cut surface	site prep.	89	nd	0.0010
Cold Spr.	240	8	soil spot	site prep.	90	nd	0.0010
Cold Spr.	240	11	soil spot	site prep.	90	nd	0.0010
Jessieville	630	30	soil spot	site prep.	90	nd	0.0020
Jessieville	630	30	soil spot	site prep.	90	nd	0.0020
Jessieville	631	7	soil spot	site prep.	90	nd	0.0020
Jessieville	631	7	soil spot	site prep.	90	nd	0.0020
Jessieville	631	7	soil spot	site prep.	90	nd	0.0020
Oden	1050	17	soil spot	site prep.	90	0.0063	0.0020
Oden	1050	17	soil spot	site prep.	90	nd	0.0020
Fourche	466	1	soil spot	site prep.	91	0.0150	0.0020
Fourche	466	1	soil spot	site prep.	91	nd	0.0020
Jessieville	618	12	soil spot	site prep.	91	nd	0.0020
Jessieville	618	12	soil spot	site prep.	91	nd	0.0020
Jessieville	621	23	soil spot	site prep.	91	0.0050	0.0020
Jessieville	621	23	soil spot	site prep.	91	nd	0.0020
Kiamichi	231	19	soil spot	site prep.	91	0.0051	0.0010
Kiamichi	231	19	soil spot	site prep.	91	nd	0.0010
Kiamichi	231	19	soil spot	site prep.	91	nd	0.0010
Mena	856	7	soil spot	site prep.	91	nd	0.0020

Velpar Monitoring Results (continued)

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Mena	856	7	soil spot	site prep.	91	nd	0.0020
Poteau	1282	2	cut surface	release	91	nd	0.0020
Winona	1409	25	soil spot	site prep.	91	nd	0.0010
Winona	1451	21	soil spot	site prep.	91	nd	0.0010
Winona	1420	25	soil spot	site prep.	92	nd	0.0010
Winona	1420	25	soil spot	site prep.	92	nd	0.0010

Herbicide Scan Monitoring Results

District	Compt.	Stand	Application method	Purpose	FY	Herbicide Conc.	Detection Limit
Choctaw	hwy259		mech. foliar	row	90	nd	varied
Choctaw	hwy270	59(1)	mech. foliar	row	90	nd	varied
Choctaw	hwy270	59(2)	mech. foliar	row	90	nd	varied
Choctaw	hwy271	1004	mech. foliar	row	90	nd	varied

Appendix B

Lab Comparison

District	Compt.	Stand	Method	Purpose	University of GA herbicide conc.	Dow Elanco herbicide conc.	Detection Limit
Caddo	35	2	cut surface	site prep.	0.0103	0.0051	0.001
Caddo	35	2	cut surface	site prep.	nd	nd	0.001
Caddo	35	2	cut surface	site prep.	nd	nd	0.001
Caddo	55	5	cut surface	site prep.	0.1440	0.06837	0.001
Caddo	55	5	cut surface	site prep.	nd	nd	0.001
Caddo	55	5	cut surface	site prep.	0.00142	nd	0.001
Caddo	97	8	cut surface	site prep.	nd	nd	0.001
Caddo	97	8	cut surface	site prep.	nd	nd	0.001
Caddo	113	6	cut surface	site prep.	0.0104	0.00536	0.001
Caddo	113	6	cut surface	site prep.	nd	nd	0.001
Caddo	113	6	cut surface	site prep.	0.1368	0.05885	0.001
Jessieville	639	23	hand foliar	release	nd	nd	0.001
Jessieville	639	23	hand foliar	release	nd	nd	0.001
Oden	1102	19	cut surface	site prep.	0.0018	0.00168	0.001
Oden	1102	19	cut surface	site prep.	nd	nd	0.001
Winona	1435	18	cut surface	site prep.	nd	nd	0.001
Winona	1435	18	cut surface	site prep.	nd	nd	0.001
Womble	1628	9	cut surface	site prep.	nd	nd	0.001
Womble	1641	22	cut surface	site prep.	nd	nd	0.001
Womble	1643	29	cut surface	site prep.	nd	nd	0.001
Womble	1643	29	cut surface	site prep.	0.0090	0.00658	0.001
Womble	1643	35	cut surface	site prep.	nd	nd	0.001
Womble	1643	35	cut surface	site prep.	nd	nd	0.001
Womble	1659	5	cut surface	release	nd	nd	0.001
Womble	1659	5	cut surface	release	nd	nd	0.001
Womble	1672	6	cut surface	site prep.	nd	nd	0.001
Womble	1672	6	cut surface	site prep.	nd	nd	0.001
Womble	1679	7	cut surface	site prep.	0.0010	nd	0.001
Womble	1679	7	cut surface	site prep.	nd	nd	0.001
Womble	1688	8	cut surface	site prep.	0.0070	nd	0.001
Womble	1688	8	cut surface	site prep.	nd	nd	0.001
Womble	1690	23	cut surface	release	nd	nd	0.001
Womble	1690	23	cut surface	release	0.0017	nd	0.001